NURSERY NOTES

Forest Resources Branch
Queen's Park, Toronto, Ontario
September 1985

No. 115

MEASURING PLANT MOISTURE STRESS ON THE NURSERY USING THE BUCKET METHOD

Introduction

Plant Moisture Stress (PMS) is a measure of the internal moisture stress that occurs in the wood vessels, or xylem, of plants. The level of PMS in the plant depends upon:

1) The supply of moisture from the soil. This depends on the Soil Moisture Tension (SMT), the Available Soil Moisture Content and on the ability of the plant to absorb moisture through the roots.

2) The atmospheric demand for moisture. This is determined by the amount of solar radiation, the severity of leaf surface (and air) temperature, the relative humidity, the drying power of the air which is best expressed as the Vapour Pressure Saturation Deficit, and the wind speed.

3) The ability of the plant to control transpirational moisture loss by stomatal closure. This varies between species.

The measurement of PMS is particularly valuable in forest tree nurseries because it can be used in the following situations:

1) To check the PMS of stock in the nursery beds to determine whether or not the irrigation is adequate.

2) To monitor the PMS of stock at time of lifting, during transplanting, grading and packing to ensure it remains at an optimal level.

3) To check the PMS of stock at the time it is shipped from the nursery to ensure that only stock that is at an optimum is shipped.

4) To check and monitor the PMS of stock at time of arrival in the field at : a) the planting site, b) refrigerated storages (snow caches or refrigerated semi-trailers), or c) holding areas to ensure it is at and maintained at an optimum.

5) To check and monitor the PMS of outplanted stock during planting and during the post-outplanting period to diagnose problems associated with plantation establishment.

Nursery stock growing in well irrigated nursery beds varies in PMS throughout the diurnal cycle. The PMS of bareroot stock is always lowest just before dawn. It then rises to a high in the late morning and remains on a rough 'plateau' through the afternoon.

Nursery stock growing in poorly irrigated nursery beds also varies in PMS throughout the diurnal cycle but the predawn PMS is invariably higher than that recorded in well irrigated beds. In addition the 'plateau' is reached sooner and the mean PMS recorded on the 'plateau' is usually much higher than for stock in well irrigated beds.

For white spruce (*Picea glauca* (Moench) Voss), black spruce (*Picea mariana* (Mill.) B.S.P. and Jack pine (*Pinus banksiana* Lamb.) growing in well irrigated beds (SMT <0.5 bar) on the Thunder Bay Forest Nursery the average pre-dawn PMS in the May and June was found to range from 3 to 5 bars, and the average PMS on the afternoon plateau from 15 to 18 bars (Day and Walsh 1980).

The diurnal variation in PMS makes its measurement inconvenient on the nursery. The best time to measure PMS is just before sunrise when it is at its lowest point, when temperature and wind are at a minimum. It is not usually convenient to measure PMS before dawn on most forest tree nurseries because it is not during 'normal working hours', and it is convenient to measure PMS throughout the day so that the PMS of stock can be monitored during lifting, grading, packing and shipping etc. In Day and Walsh (1980) methods of correcting the PMS of white spruce, black spruce and jack pine measured at any time of day are given to facilitate the interpretation of PMS measurements made in operational nursery practice. As the methods of correcting PMS during periods of severe fluctuation are only approximate, Dr. Gary Ritchie of the Weyerhauser Company in Centralia Washington suggested that it might be possible to extend the predawn PMS into working hours by placing buckets over the stock to be tested on the preceeding evening.

Objective

To test the 'Bucket Method', or placement of buckets over the stock the preceeding afternoon, to limit morning rise in PMS of Jack pine as a possible means of estimating 'predawn' PMS during morning working hours the next day.

Methods

2 + 0 Jack pine seedlings of Site Region 25-4400 origin in Compartment No. 27 on the Thunder Bay Forest Station were selected for the tests which were carried out in August 1984.

Three treatments with ten replications each were set-out in a fully randomized experimental design was set out in Compartment No. 27. On August 2nd, 15th and 29th ten sample areas were located at random. Each sample area was subdivided into three subsample areas each of which was designated for one of the treatments to be tested the next day. At 4:00 p.m. the ten (10) subsamples slated for the 'bucket method' were covered with upturned buckets. The next day the following three treatments were evaluated:

1) Predawn PMS measurement (before sunrise) of stock exposed to the air (Control).
2) Mid-morning PMS of stock covered by buckets at 4:00 p.m. the preceeding day.
3) Mid-morning PMS measurement of stock exposed to the air.

The PMS measurements were made on August 3rd, 16th and 30th with two portable pressure chambers identical to those described by Day and Walsh (1980). The two pressure chambers were used at the same time to speed up the work and to maintain a close schedule. Five seedlings were measured in each sample area, so that 50 seedlings were measured in each treatment. The upper 6 cm of a lateral in the terminal whorl or the leader of each seedling was tested using the methods prescribed by Day and Walsh (1980).

Results

The PMS of the 2 + 0 Jack pine stock generally followed the same pattern on each of the test days (Figure 1). It was lowest before sunrise or 'predawn' even though the stock tested at this time were exposed to the air. At mid-morning, the stock protected by the upturned buckets had a higher PMS than at 'predawn', and those exposed to the air had the highest PMS.

The increase in PMS between the 'predawn' and mid-morning measurements varied considerably on each test day (Table 1 and Figure 2). Analysis of variance of the main effects (the three days combined) showed that the mean PMS of each of the three treatments was significantly different ($p = 0.05$). Thus the PMS of exposed stock measured 'predawn' differed from that of stock protected by upturned buckets in the mid-morning, and the PMS of both these types of stock differed from that of exposed stock in the mid-morning.

The mean PMS values recorded on each test day (Figure 1) appear to differ because of differences in weather conditions each day which are presented in Table 1 and Figure 2.

August 3rd
This was the warmest and driest test day (Table 1 and Figure 2). Owing to the warm dry day the differences in PMS between 'predawn' exposed and mid-morning covered was -2.16 bars, that between mid-morning covered and exposed was -2.37 bars and *all differences were significant.*

August 16th
This was the coolest and most humid test day (Table 1 and fugure 2). Owing to the cool humid weather the differences between 'predawn' exposed and mid-morning covered was only -1.26 bars, that between mid-morning covered and exposed was only -0.87 bar and *none of the differences were significant.*

August 30th
This was again a warm dry day. It differed from August 3rd because it had a very low relative humidity during the mid-morning measurement (Table 1 and Figure 2). The difference between the 'predawn' exposed and mid-morning covered treatments was only -1.42 bars, which was not significant, that between mid-morning covered and exposed was -4.0 bars which was highly significant.

Discussion

The results show that the 'predawn' PMS of 2 + 0 Jack pine nursery stock cannot be reliably evaluated using the bucket method. The results show that placing upturned buckets over Jack pine stock reduced the PMS measured during the mid-morning period (10:00 to 10:30 a.m.) by from -0.87 bar on August 16th, a cool humid day, to -4.0 bars on August 30th, a warm dry day. The effect of the upturned buckets was to reduce transpiration stress by trapping humid air and to protecting the seedlings from drying in the wind. This effect was much less pronounced on the 16th than on the 3rd or 30th of August because of the warmer, drier and more turbulent air on the two latter days. It seems probable that the higher PMS values of the stock covered by the buckets on August 3rd and 30th may mainly be caused by higher temperatures on those days and is probably not be due to lower humidity or greater turbulence beneath the buckets. The non-significnat differences of -1.26 and -1.42 bar between the 'predawn' and mid-morning covered mean PMS values on August 16th and 30th might be considered acceptable, but a significant difference of -2.16 bars on August 3rd is not. Because the bucket method does maintain the PMS close to the predawn level on warm, turbulent days with low humidity, it should not be used to estimate the 'predawn' PMS of Jack pine.

To measure the PMS of Jack pine or white or black spruce stock at any time of day it is better to use the methods described in Day and Walsh (1980). These methods consist of: 1) Measuring the mean PMS, 2) Determining the mean temperature in C° and relative humidity in %, 3) Adjusting the mean PMS using a PMS calculator, and 4) Determining whether the stock is in 'Normal', 'Moderate', 'High', 'Excessive' or 'Lethal' PMS ranges.

When Day and Walsh's method is applied to the PMS values determined in this study all the adjusted PMS values either fall into the upper 'Normal' or lower 'Moderate' ranges. As Day and Walsh (1980) calibrated their correction curves during the late spring and early summer, it is probable that the low 'Moderate' values are appropriate for August because PMS tends to rise in the latter part of the growing season.

The use of the 'bucket method' to determine 'predawn' PMS is not recommended. It is better to follow the detailed instructions given in, "A manual for using the pressure chamber in nurseries and plantations" (Day and Walsh 1980) to interpret daytime PMS measurements of 2+0 Jack pine stock.

Literature Cited

Day, R. J. and S. J. Walsh. 1980. A manual for using the pressure chamber in nurseries and plantations. Lakehead University, School of Forestry. Silv. Rept. 1980-2. 49 p.

Table 1. A comparison of mean Temperature (°C), Relative Humidity (%) and Vapour Pressure Saturation Deficit with PMS on August 3, 16 and 30 1984.

Attribute Measured[1]	August 3	August 16	August 30
1) Temperature (°C)			
a) Predawn	12.6	10.8	10.8
b) Mid-morning	23.3	15.8	19.2
2) Relative Humidity (%)			
a) Predawn	95.0	90.5	83.0
b) Mid-morning	62.0	67.0	42.5
3) Vapour Pressure Saturation Deficit (mm Hg)			
a) Predawn	0.55	0.92	1.65
b) Mid-morning	8.17	4.42	9.60
4) Plant Moisture Stress (Bars)			
a) Predawn (exposed)	7.53	7.14	8.96
b) Mid-morning (covered)[2]	9.69	8.40	10.38
c) Mid-morning (exposed)	12.06	9.27	14.38

Notes: [1] Predawn measurements for T °C and RH% are the mean of the 6:00 and 7:00 a.m. measurements; those for the Mid-morning are the mean of the 10:00 and 11:00 a.m. measurements.

[2] Covered with buckets.

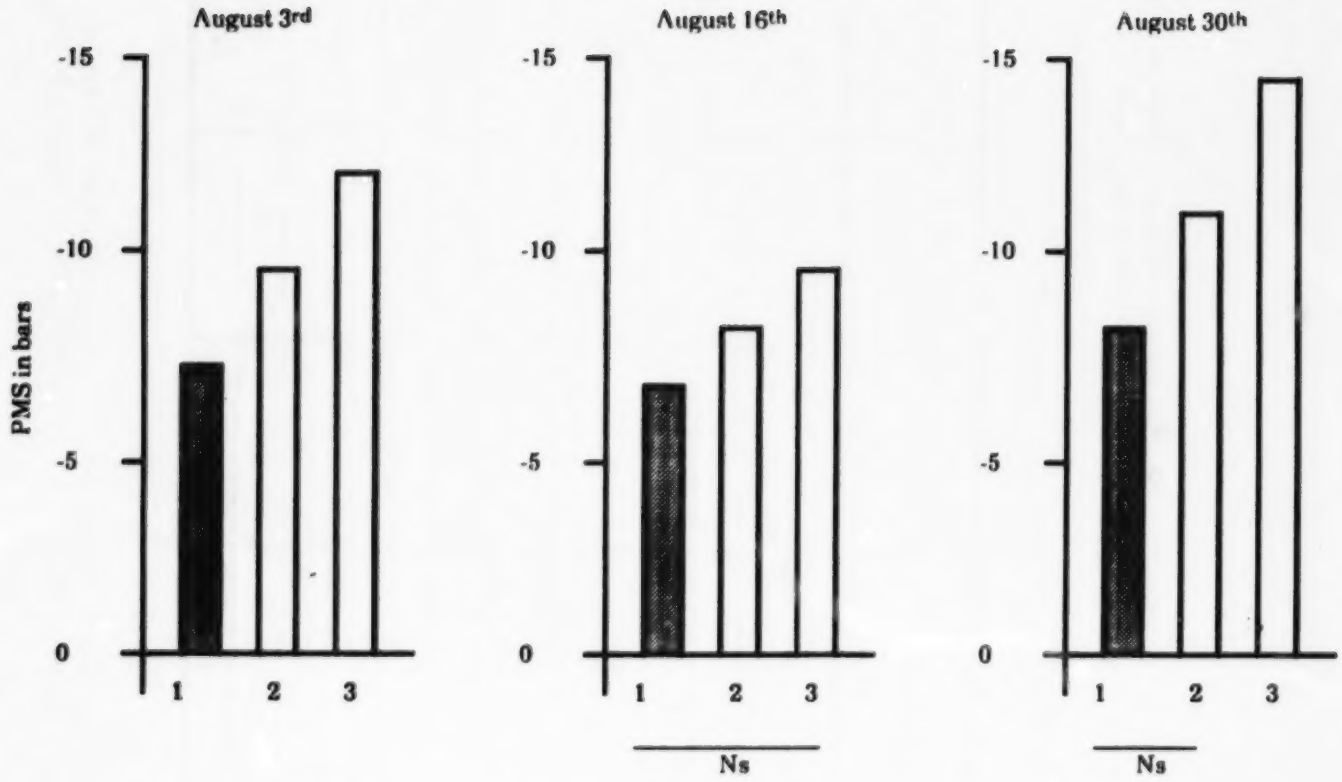

Figure 1. The PMS of well irrigated 2+0 Jack pine nursery stock: 1) 'Predawn' exposed to the air, (2) Mid-morning covered with buckets, and 3) Mid-morning exposed to the air on three days in August 1984. Treatments connected by a solid line were non-significant ($p = 0.05$).

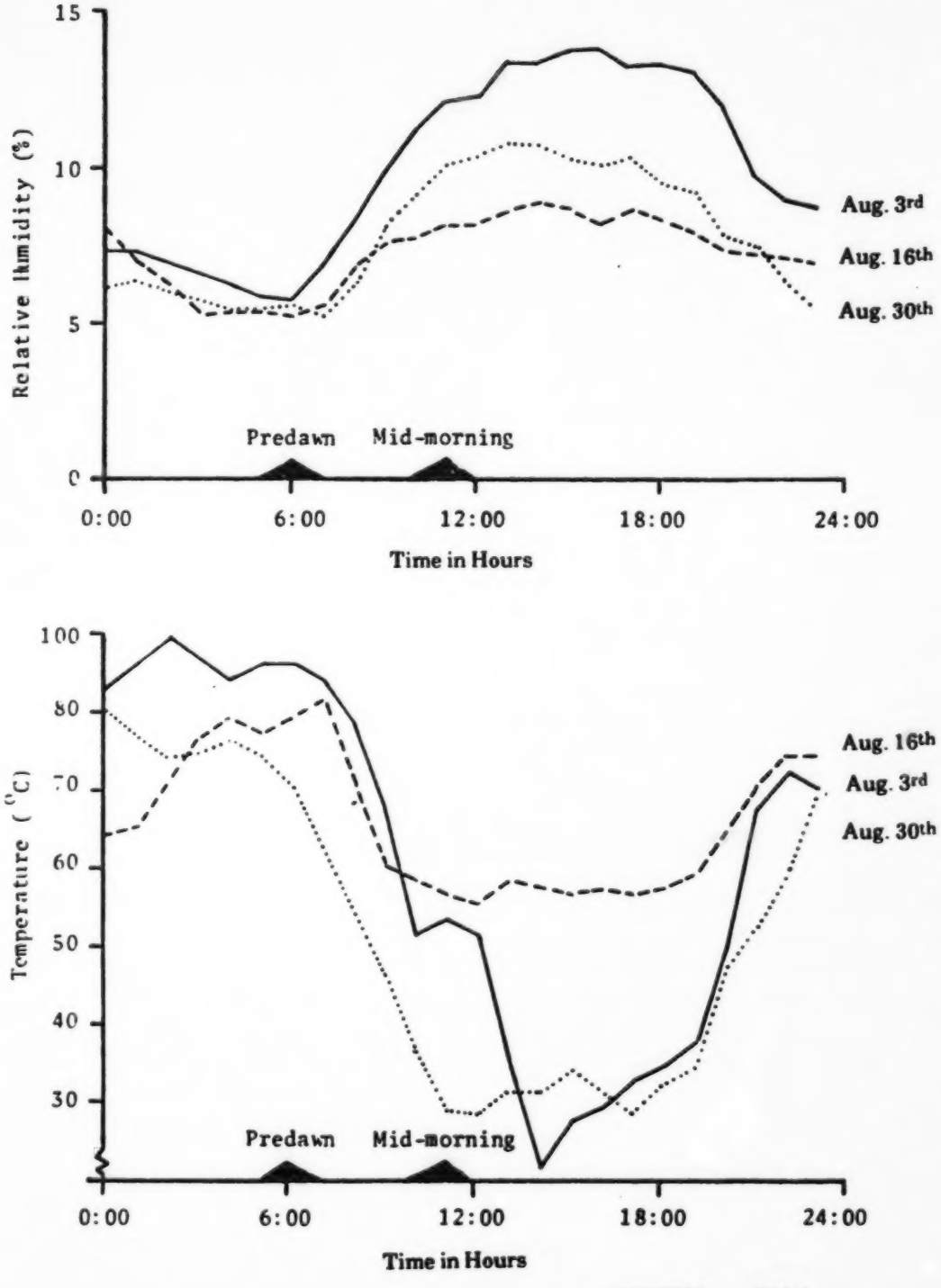

Figure 2. **The march of Temperature (°C) and Relative Humidity (%) throughout the day on August 3, 16 and 30 1984. Weather data from Thunder Bay airport.**

Nursery Note No. 115 was prepared by Professor R.J. Day, School of Forestry, Lakehead University, Thunder Bay, Ont. and C. (Stern) Krishka, Nursery Forester, Ontario Ministry of Natural Resources, Thunder Bay Forest Nursery, Thunder Bay, Ontario P7C 4T9